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The Use of Dynamite in Farming.

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One of the chief problems in successful farming in Hawaii is the maintenance of the proper physical condition of the soil. Many soils are extremely heavy, being composed of fine clay and silt. Such soils are easily puddled and compacted, thus becoming relatively impervious to air and water.[1] While there is rarely, if ever, a true hardpan underneath the ordinary cultivated surface of Hawaiian soils, the soil beneath the depth to which cultivation is ordinarily practiced soon becomes fully as hard and impervious as the hardpans which have given so much trouble in California, the Southern States and other parts of the mainland. This sort of hardpan which is really a mere compacting of the soil from the combined effects of moisture and pressure, is observed in a large proportion of the gardens and cultivated fields in Hawaii. No matter how deep the soil may be plowed nor how thoroughly it may be harrowed or pulverized before planting, a layer of compact soil is soon formed just below the depth to which the cultivator may reach. This compacting becomes more pronounced as time goes on until in fields upon which are grown such crops as pineapples the lower layers

1. Hawaii Press Bulletin No. 29.

of the soil are altogether too firm for the best root growth or for the penetration of air or water long before the first crop reaches maturity. Since it is the ordinary custom to take one or two rattoon crops from the same field, the soil naturally becomes more and more unsuited to the best growth of the rattoon crops. It is a common matter of observation that while the upper two or more inches of soil may be perfectly pulverized by cultivation, that part of the soil which lies below is firmly packed into an impervious mass resembling vulcanized rubber or dried putty in consistency.

If soils of this character are carefully plowed, the fresh layer exposed to the air may soon disintegrate into granules and may be well pulverized by cultivation, while the previously pulverized layer now lying underneath soon returns to a compacted condition. If heavy rains occur the soil beneath takes on the puddled, impervious condition within a short time after plowing and thorough cultivation. During the prevalence of long periods of drought wide and deep cracks may form by the great shrinking of the colloidal matter in the soil. Cracks of this sort form to the depth of four feet or more and sometimes to a width of three or four inches unless careful cultivation is practiced. In soil which has become packed together into a solid mass neither air nor water can penetrate deeply or at least not rapidly enough for the purposes of plant growth. On this account great difficulty is experienced in irrigation. While the water-holding power of soils in Hawaii seems to be relatively high, yet the impervious nature of these soils when once compacted does not admit the penetration of water at a rapid enough rate to prevent the excessive loss of irrigation water from the surface by evaporation. It, therefore, comes about that in times of heavy rain the surface of the soil is over-saturated with water and superficial drainage must be provided to prevent erosion of the soil and also to prevent the exclusion of the air through over-saturation with water. Moreover, when drought occurs on the soils in question the rise of water from below takes place altogether too slowly to suit the demands of the plant and crops therefore suffer from drought to an undue extent.

One of the most serious consequences of the unfavorable physical condition of such soils is the fact that the nitrogen in

the soils becomes unavailable. Except where good conditions for aeration are brought about, the amount of nitrogen in the form of either ammonia or nitrate is decidedly small. In some Hawaiian soils the chemical state of iron salts becomes unfavorable where proper aeration is impossible. Another injurious effect of improper aeration consists in the deterioration of the physical structure of the soil with special reference to its lack of granules.

From numerous observations made on soils in different localities under different crops it is obvious that success in farming depends to a large extent upon the maintenance of proper conditions for aeration and drainage. Otherwise, it seems impossible to hold the nitrogen in the soil in an available form or to bring about a suitable regulation of the water supply or distribution of air among the soil granules.

In attempts to overcome the troubles arising from the presence of a hardpan underneath the cultivated surface of Hawaiian soils, various devices have been used. In some of the pineapple fields good results have followed the use of surface ditches which carry off the surface water in times of excessive rain and thus prevent the soils from being packed together as firmly as would otherwise be the case. The cost of ordinary drain tiles, which have to be imported into Hawaii, is rather too great to allow their economic use on a large scale. There is apparently no clay in Hawaii which can be sucessfully used in making the ordinary red drain tiling. Recently some attention has been given to the use of cement tiles, and machinery for this purpose has been brought from the mainland. It is not yet known how expensive cement tiles will be. A few experiments have been made with fairly satisfactory results, using square redwood drains. Redwood will last at least for a number of years in the soil and the expense for preparing such drains is lower than the use of clay drain tiles even near the factory where they are made.

USE OF DYNAMITE.

On account of the difficulties which have been experienced in bringing about a proper drainage and aeration of Hawaiian soils, the station has for a number of years carried on experi-

ments in the use of dynamite. The holes for receiving sticks of dynamite cannot be drilled in our heavy soils by the use of an ordinary soil auger. In fact, even soil samples cannot be taken by this means in the heaviest soils. The best method of making holes for dynamite consists in driving an iron bar into the soil by means of a heavy hammer. The sticks of dynamite used for this purpose are 1¼ inches in diameter by 8 inches in length. The iron bar need therefore not be more than 1½ inches in diameter and should be about 4 feet in length. A 16-pound hammer is sufficient to drive the bar to a depth of 2½ feet with a few vigorous blows. The bar can then be removed by tapping a few times on the side to set it loose from the surrounding soil. It may then be drawn out, using some care not to allow loose soil to fall into the hole. It is not practical to make holes for dynamite in this manner in soils which are excessively dry for the reason that too much loose earth will unavoidably fall into the hole when the bar is removed.

The proper distance apart at which the holes should be driven will depend somewhat on the nature of the land to be dynamited. In general it has been found that the cracks shattered in the soil by the dynamite explosion will meet across the space when the holes are driven 8 or 9 feet apart both ways. In preparing orchard land for planting, the holes will naturally be made at such distances as it is desired to plant the trees. A few preliminary tests will determine whether a half stick is sufficient to shatter the soil or whether a whole stick will be required. When the holes are made 9 feet apart we have generally found it best to use a whole stick. The holes should be firmly tamped all the way from the stick of dynamite to the surface of the ground since otherwise the explosion results in blowing a small quantity of soil high into the air and does not shatter the underlayers of the soil. If the holes are properly tamped the force of the explosion is exercised almost entirely at a considerable depth and shows little surface disturbance. Sometimes the surface layer of the soil is merely lifted a few feet immediately over the stick of dynamite and when this result is brought about the best effect is obtained from the dynamite. If the bar is driven to a depth of 2½ feet in heavy soils the explosion commonly results in shattering cracks in ordin-

ary soils to a depth of about 4 feet and extending to about 5 feet in all directions around the charge.

Where considerable areas are to be prepared with dynamite the holes may be driven in rows 8 or 9 feet apart in the row, extending across the field. The dynamite is then placed in position with cap and fuse attached so as to reach just above the surface of the ground. By means of a gasolene blast torch one man can touch off 3 or 4 rows of dynamite fuse and keep out of harm's way.

For tree planting dynamite is confidently recommended as the best method of preparing the soil. Without the use of dynamite it is necessary to dig the hole at least 3 feet in diameter and to a depth of 2 feet. In heavy soils this will require the labor of a man for about one hour. If the hole thus prepared is filled with loose soil and the tree planted in it the tree may thrive for a year or two but the roots soon meet with the smooth and compacted surfaces at the edge of the hole through which the roots have great difficulty in penetrating. The tree is, in fact, in about the same situation as if it had been planted in a large tub. Where dynamite is used, however, cracks are formed in the soil to greater depths than would be reached by hand digging and to a distance of five or sometimes six feet on all sides, and the best conditions are thus furnished for the continued growth of the tree. The use of dynamite may, therefore, be recommended in planting papayas, avocados, mangos, bananas and other orchard fruits.

Little experience has been had in Hawaii in the use of dynamite for draining swampy places. In most localities where heavy rainfall occurs the soil is underlain with loose porous rock to such an extent that almost no running or standing water is to be seen. In a few cases, however, where small swamps were formed, dynamite was used with beneficial results, the water disappearing through the deep cracks formed by the explosion.

For most purposes considered in this connection a low grade dynamite is preferable to a high grade powder. In the experiments at the station a 25 per cent dynamite especially designed for plowing and soil preparation has been used. The explosion of this grade of dynamite is, of course, slower than that from

higher grades and the force of the explosion is much more largely used up in shattering the lower layers of soil. The brands of high grade dynamite cause too much surface disturbance and do not produce so many nor so deep cracks in lower layers of the soil and sub-soil. As indicated above when the low grade dynamite is used and the holes properly tamped there should be little disturbance on the surface and the clods of earth should not be throw up more than a few feet.

According to the experiments carried on thus far, it appears that the cost of the dynamite, caps, fuse and labor amounts to about 3 cents per hole. If holes are driven 8x8 feet apart the cost per acre will therefore be $20.40; 9x9, $16.10; 10x10, $13.05; 20x20, $3.25. The last spacing named would be about the one used in planting orchard trees. In reference to the use of dynamite in farming operations, the phrase "plowing with dynamite" is frequently used. Even if the holes are driven not more than 8 feet apart both ways, the soil is not actually plowed but is simply loosened to a depth far below that of ordinary plowing. The ordinary plowing and harrowing operations must therefore be performed in addition to dynamiting.

The use of dynamite in preparing the soil is to be considered as in the nature of a special treatment to provide for deep drainage at relatively long intervals. It is impossible to say how long the deep cracks shattered by dynamite will remain effective in Hawaiian soils. In various localities in the Southern States where dynamiting has been practiced longest, it has been found that the effect of dynamiting persists for about 10 years. If the cost of dynamiting does not exceed $25 per acre it will thus be seen that this special method of preparation is a profitable investment from the standpoint of the physical condition brought about in the soil and the consequent increase in crop yield.

The formation of deep cracks in the soil is beneficial in improving the drainage possibilities. More water can be held in the soil by reason of this additional depth of soil spaces and the movement of water takes place more rapidly both downward during rains and upward in time of drought. In some cases an actual pocket is formed by the explosion of the stick of dyna-

mite, while from this pocket numerous cracks radiate in various directions. So far as observations have been made, the beneficial effects from the use of dynamite are apparent in the growth of trees and other crops. As already stated, however, these observations have not been carried on for more than three or four years on Hawaiian soils.